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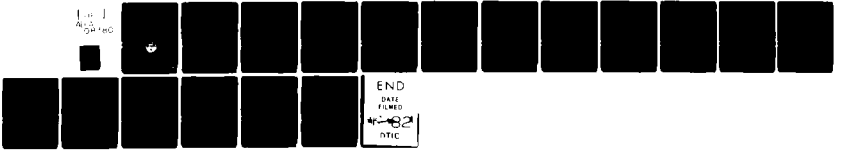

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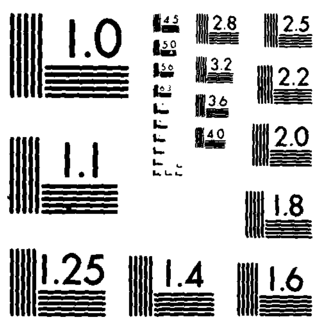

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FORECASTING STAFFING NEEDS IN A NAVY RESEARCH LABORATORY

NAVY PERSONNEL RESEARCH
AND
DEVELOPMENT CENTER
San Diego, California 92152

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November 1981

FORECASTING STAFFING NEEDS IN A NAVY RESEARCH LABORATORY

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Like many government organizations, the Navy Personnel Research and Development Center (NAVPERSRANDCEN) faces restrictions regarding the number of personnel it may hire. In order to justify its existing billets or positions, NAVPERSRANDCEN must demonstrate that it is effectively using its current allocation of billets. This, in turn, requires accurate predictions of future attrition so that the lead time associated with recruiting and hiring new personnel can precede personnel losses without incurring long periods of billet vacancy. The purpose of this effort was to provide a methodology

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capable of forecasting at the lowest level of aggregation possible the number and type of personnel vacancies far enough in advance to allow time for recruiting and hiring. Findings indicated that NAVPERSRANDCEN attrition can be forecast with a sufficient degree of accuracy.

FOREWORD

The objective of this report was to document a procedure for forecasting the level of staff hires that would ensure a 100 percent occupancy of available positions at the Navy Personnel Research and Development Center (NAVPERSRANDCEN). The report describes the essential features of a computer model for personnel planning and validation of model forecasts. Results from this model were used recently by NAVPERSRANDCEN to plan accessions for FY81 and FY82.

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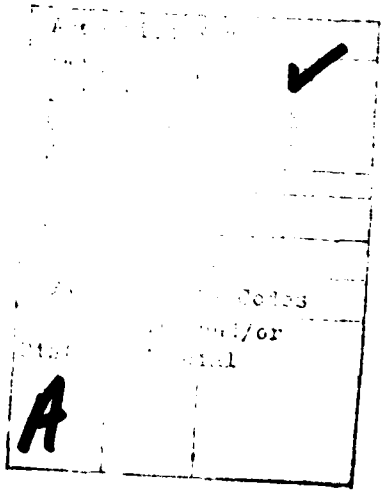

SUMMARY

Problem

Like many government organizations, the Navy Personnel Research and Development Center (NAVPERSRANDCEN) faces restrictions regarding the number of personnel it may hire. In order to justify its existing billets or positions, NAVPERSRANDCEN must demonstrate that it is effectively using its current allocation of billets. This, in turn, requires accurate predictions of future attrition so that the lead time associated with recruiting and hiring new personnel can precede personnel losses without incurring long periods of billet vacancy.

Purpose

The purpose of this effort was to provide a methodology capable of forecasting, at the lowest level of aggregation possible, the number and type of personnel vacancies far enough in advance to allow time for recruiting and hiring.

Approach

Attrition data for NAVPERSRANDCEN personnel were analyzed to determine the feasibility of forecasting personnel losses by occupational category. A set of computer programs was used to group personnel into occupational categories, determine attrition forecasting equations, and forecast future vacancies up to 5 years ahead.

Findings

1. NAVPERSRANDCEN personnel can be grouped into four distinct occupational categories whose attrition behavior is either significantly different or of special management concern: Professional, Administrative/Technical, Clerical, and Secretarial.

2. Sufficient historical attrition data exist so that attrition forecasting equations could be developed for the four groups.

3. Validation results over a 9-month period indicated a sufficient degree of attrition forecasting accuracy.

4. Given NAVPERSRANDCEN billet requirements for the four groups for 1981 and 1982, attrition forecasting equations indicated that 42 and 45 new hires, respectively, are needed to obtain 100 percent billet occupancy.

Conclusions

This methodology offers promise in forecasting staffing needs at institutions similar to NAVPERSRANDCEN.

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INTRODUCTION

Problem and Background

Like many government organizations, the Navy Personnel Research and Development Center (NAVPERSRANDCEN) operates under personnel constraints expressed as an upper bound on the number of positions or billets. In order to justify its existing positions or request additional billets, NAVPERSRANDCEN must demonstrate that it is using its current allocation fully. This requires that existing billets be filled as soon as they become vacant. Thus, we must know how many of each type of personnel to hire and when to hire these personnel. The knowledge necessary for intelligent hiring decisions involves accurate estimates of future personnel losses. Vacancies must be predicted with sufficient lead time and accuracy to enable recruiting and hiring actions and training to occur. Obviously, then, it is necessary to initiate recruiting and hiring actions before losses occur if existing billets are to remain filled.

With the increasing specialization of many jobs, longer recruiting and/or training periods are required to fill vacancies. Consequently, the more "lead time" an organization has to identify the location of vacancies, the more successful it is likely to be in maintaining an adequate work force.

Purpose

The purpose of this effort was to provide a methodology capable of forecasting, at the lowest level of aggregation possible, the number and type of personnel vacancies far enough in advance to allow time for recruiting and hiring.

APPROACH

A convenient approach to this problem is described in a Civil Service publication (Clark, 1977), which provides a rationale for civilian manpower planning and a set of computer programs to assist personnel managers.

Much of personnel planning centers around the problem of forecasting personnel losses or attrition. Personnel losses can be divided into two types: (1) actuarial (death, disability, and retirement) and (2) voluntary quits. For actuarial losses, simple loss probability tables have been compiled based on employees' age and sex. These tables would obviously vary by type of industry, culture of work force, work process, and a wide variety of other factors. Once constructed, these tables can be readily applied to an organization's work force to produce an estimate of actuarial losses.

A more difficult and significant problem is forecasting the number of voluntary quits. Since the number of voluntary quits, relative to actuarial losses, is usually quite large, the number of accessions required by an organization is largely dependent on estimates of voluntary separations. Figure 1 depicts a method for arriving at the total number of new accessions needed for 1 year: It is the sum of all losses occurring during the year, plus any growth anticipated in the total number of billets. While conceptually simple, an organization may fall short of the total number of accessions needed if losses are filled only after they occur. Clearly, vacancies must be anticipated if positions are to be continuously filled by incumbents.

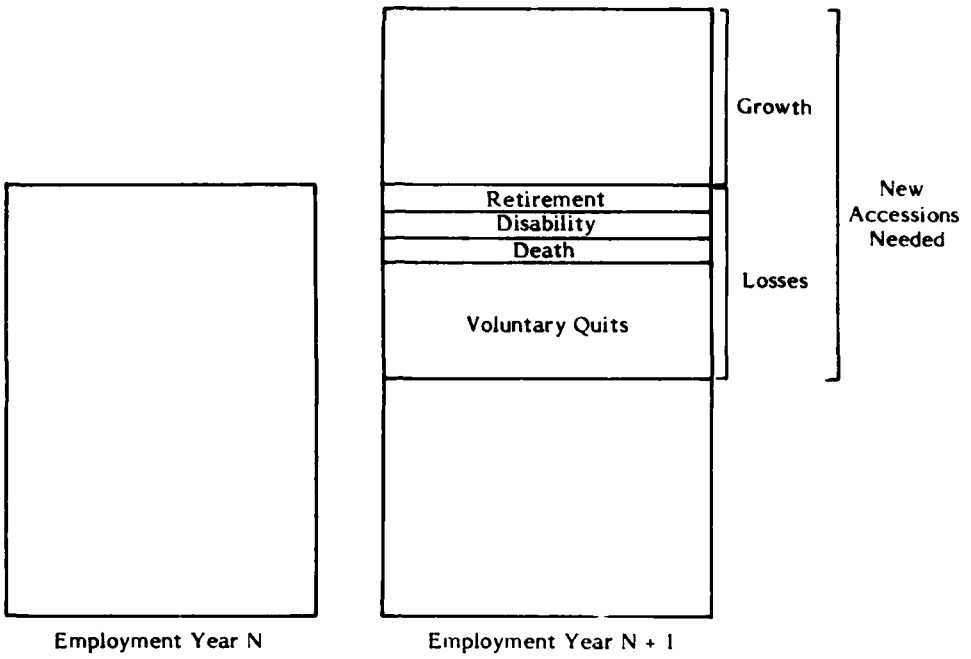

Figure 1. Typical change in employment of an organization.

To forecast voluntary losses, a personnel data base is essential. This data base should include, at the very least, a person's date of entry into the organization, the departure date (if any), and data regarding the person's occupation and grade level. In addition, a person's birth date and sex are required to compute actuarial probabilities. From this data set, a "survival curve" can be estimated.

A hypothetical survival curve appears in Figure 2. Here, 50 percent of all employees leave sometime prior to completing 4 years of service (YOS) and 20 percent reach the 10-year point. From this curve, one can construct a YOS distribution for any number of employees who adhere to this retention pattern. The curve can also be used to estimate the number of losses (voluntary quits) from this group of employees for any year in the future. For example, if 66 percent stay through at least 3 years but only 50 percent stay through at least 4 years, we can estimate that 24.2 percent (66 - 50/66) of those with at least 3 YOS but less than 4 YOS will leave during a 1-year period. If there are currently 10 employees in this YOS range, an average of 2.4 can be expected to leave before they reach 4 YOS.

If we know, with some statistical confidence, the shape of the survival curve(s) for an organization's employees, we can then forecast losses (Clark, 1977). This approach applies to full-time employees, as opposed to part-time or summer hires, since the two groups differ markedly in behavior. Also, the statistical procedures are more effective for groups of about 30 employees or more. For those occupations with small groups of employees, it is statistically necessary to combine groups into larger aggregations so that a modicum of reliability can be obtained. This procedure and many others are described in more rigorous terms in Bartholomew and Forbes (1979).

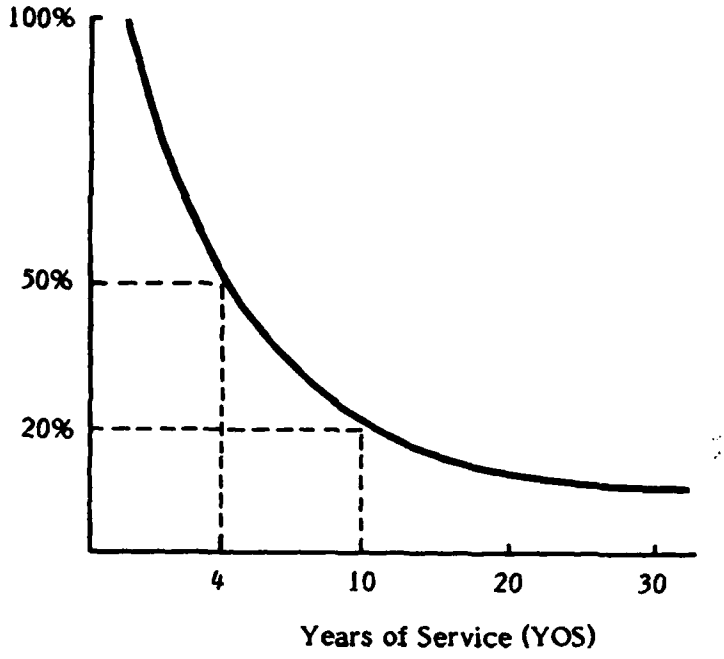

Figure 2. Hypothetical survival curve.

The technique described below assumes a lack of longitudinal data, which is the case for most organizations. Longitudinal data consist of counts of employees of each employee group or cohort (defined by time of entry, occupation, sex, grade, age, etc.) remaining on board after certain lengths of time. Even if longitudinal data are available, they may be difficult to use because of wide fluctuations in hiring patterns from year to year, or small numbers of employees for various occupational groups. Alternatives to longitudinal files are described in Grinold and Marshall (1978), as well as in Bartholomew and Forbes (1979).

For this application, a data file consisting of all employees hired during the last several years was used. With more years of data, better estimates of the survival curve for each group of employees could be obtained. The data file consisted of four items for each employee: (1) occupation or job series, (2) grade at hire, (3) date of hire (month/year), and (4) date of separation (month/year), if any. Also required is a "file ending date," which is the closing date of the file and of the time period under study. These data are used in a computer program, called LPFILE, developed by the U.S. Civil Service Commission (Clark, 1977) to compute (1) an employee's actual tenure in his occupation (i.e., date of separation/date of hire) and (2) the maximum tenure of an employee during the selected time span, if he or she had not separated before the end of that period. Obviously, if an employee has not separated, the actual time on board equals the possible time on board.

As an example, consider a group of 10 employees who were hired over a 4-year period in a particular occupation (Table 1). For this group of employees, three (employees 1, 3, and 4) were still in service at the end of the observed time. Program LPFILE translates these data into log-probability (x,y) retention pairs in order to fit a curve similar to that shown in Figure 2. The x-coordinate represents YOS and the y-coordinate, percent retained. Thus, the sample data in Table 1 would be transformed into the data in Table 2.

Table 1

Sample Employee Data

Employee	Could Have Served (Years)	Actually Served (Years)
1	.78	.78
2	1.12	.42
3	1.53	1.53
4	1.60	1.60
5	1.89	1.01
6	2.23	2.12
7	2.54	2.44
8	2.63	1.40
9	3.15	2.60
10	3.70	3.40

Table 2

Sample (x, y) Log-probability Retention Pairs

Years of Service (x)	Percent Retained (y)
.78	.90 (9/10)
1.12	.78 (7/9)
1.53	.75 (6/8)
1.60	.71 (5/7)
1.89	.67 (4/6)
2.23	.60 (3/5)
2.54	.50 (2/4)
2.63	.33 (1/3)
3.15	.50 (1/2)
3.70	.00 (0/1)

The first percent retained figure in Table 2, 90 percent, is obtained from the fact that all 10 employees could have served .78 years, but only nine did. The next one, 78 percent, signifies that nine employees could have served 1.12 years, but only seven did. Program LPFILE transforms the above data so that a linear least squares routine can be used to fit a line through the points. The x-values YOS are transformed by taking logarithms and the y-values (percent retained) are transformed into the number of standard deviations from the mean of a normal curve (mean = 0, standard deviation = 1). For example, the first x-value would become log (.78) = .1079 and the first y-value, using a standard normal curve conversion table, would become 1.2816 (i.e., 90% of the area under a normal curve lies within 1.2816 standard deviations of the mean). The best linear

relationship (using least squares estimation) is obtained by using these two transformations.

APPLICATION

Applying the above procedure to NAVPERSRANDCEN personnel data constitutes the main part of the application. Preliminary to the analysis, it was necessary to determine the appropriate occupational groupings. The 147 personnel hired during the 4-year period (1975-1979) were classified by General Schedule (GS) series and grade. Although the grade groupings did not reflect clear differences in retention behavior, personnel classified by GS series did show significant differences. The largest categories of personnel for which data were available included those in GS-334 (Computer Specialists), GS-180 (Psychologists), GS-1515 (Operations Research Analysts), GS-322 (Clerical), and GS-318 (Secretaries). Using LPFILE, log-probability equations were determined for each group. Then, program LPTEST (Clark, 1977) was used to test whether the retention behavior of two or more groups was statistically different. If not, similar groups could be combined into a single group. Since the test revealed that the retention behavior of NAVPERSRANDCEN Psychologists, Operations Research Analysts, and Computer Specialists was similar, they were all grouped together. Alternatively, the LPTEST showed that the retention behavior of Secretaries and Clerical personnel was significantly different. Thus, they remained in separate categories.

Thus, three major occupational groups were established--Professionals, Clerical, and Secretarial. In addition, a fourth group (Administrative/Technical) was created for personnel management needs. All NAVPERSRANDCEN personnel were classified into one of these four occupational groups; the GS series included in these groups are provided in Table 3. Four log-probability equations were then developed (Table 4), which are graphically depicted in Figure 3. As shown, the Professional group exhibits the highest retention pattern and the Clerical group, the lowest. The Secretarial group has high retention rates in the early YOS, but drops off sharply thereafter. Finally, the Administrative/Technical retention curve closely mirrors that of the Professionals.

Table 3

Occupational Groups by GS Series

Professional	Admin./Tech.	Clerical	Secretarial
101	099	305	318
110	181	312	
180	203	318	
330	205	322	
334	301	1087	
1515	332	1106	
1520	335	2132	
1529	341		
1530	356		
1710	504		
1712	505		
	525		
	560		
	599		
	856		
	1020		
	1083		
	1102		
	1410		
	1411		
	1412		

Note. For Series 318, those in Grades 4 and below are included in the Clerical group; and those in Grades 5 and above, in the Secretarial group.

Table 4

NPRDC Log-Probability Equations
(x = YOS, y = Percent Retained)

Group	Equation
Professional	y = 1.34638 + (-1.37968)x
Admin./Technical	y = 1.40863 + (-1.81534)x
Clerical	y = .33953 + (-1.71005)x
Secretarial	y = 1.87340 + (-3.67368)x

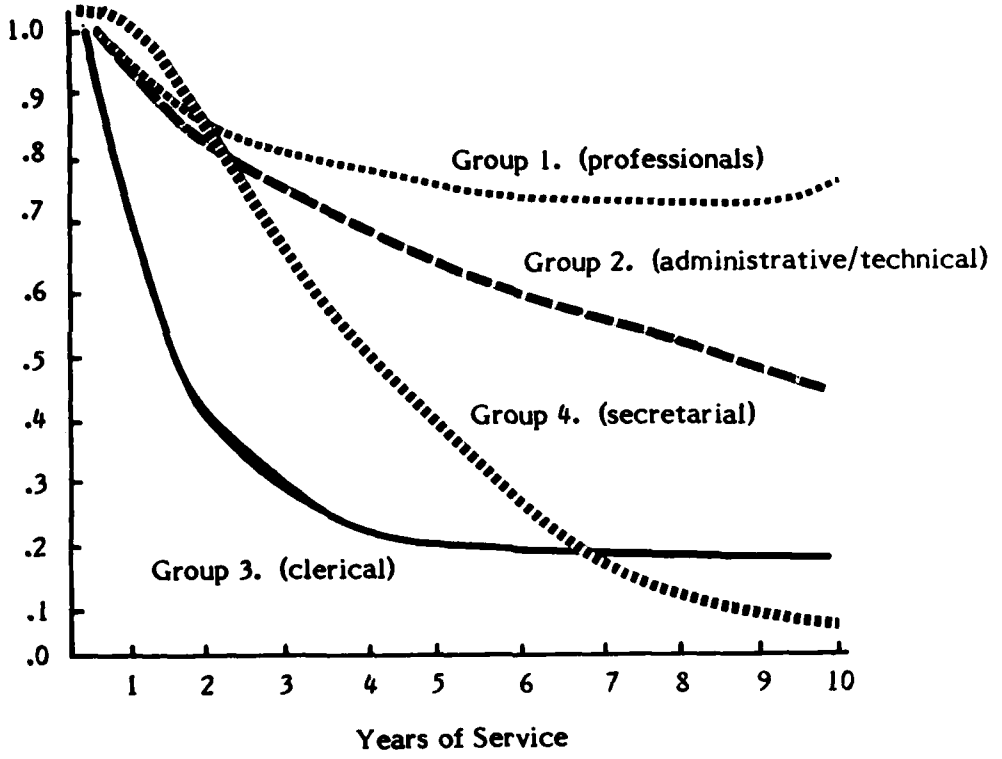

Figure 3. Retention curves for four occupational groups.

VALIDATION

Although estimating retention curves is a simple process, the usefulness of the curves rests on their ability to forecast losses. Stated differently, their value depends upon people behaving as the curves say they will. To test the validity of the log-probability equations for the four groups, program HIREST (Clark, 1977) was used to forecast losses for the period 1 October 1979--1 June 1980. This program applies the log-probability equations to a personnel roster in order to forecast losses. The forecasted values were then compared to the observed (actual) losses for that same period.

Requirements for HIREST include a data file consisting of the entire personnel inventory. The 246 full-time NAVPERSRANDCEN employees on board 1 October 1979 were classified into the four groups (175 Professional, 45 Administrative/Technical, 33 Clerical, and 13 Secretarial). The data file consisted of each person's birth date, sex, entry on duty (EOD) date, and service completion date (SCD). Program HIREST forecasts voluntary quits (through the log-probability equations and EODs) as well as retirements (using SCDs) and deaths (using sex and birth dates). For the latter, HIREST has built-in death and retirement probabilities based on historical data compiled by the U.S. Civil Service Commission and the Bureau of the Census.

Table 5, which provides the results for an 8-month forecast period, shows that the overall accuracy of the forecasting technique is quite good. The only major discrepancy appeared to be with the Administrative/Technical group, where four losses were forecast while only two actually occurred. Even so, a later check of losses after 1 June 1980

showed the group "catching up" with the forecast. In short, this group's losses were not occurring uniformly throughout the year. Obviously, an attempt to forecast losses for a relatively small group over a short period of time will result in higher error rates than would otherwise be the case.

Table 5

Validation Results

Group	On Board 10/1/79	Actual Losses 10/1/79--6/1/80	Forecasted Losses 10/1/79--6/1/80	Difference
Professional	175	10	9	-1
Administrative/ Technical	45	2	4	2
Clerical	33	5	6	1
Secretarial	13	2	2	0
Total	266	19	21	2

FORECASTING REQUIREMENTS

When deciding how many personnel to hire in the future, personnel managers must classify prospective hiring actions by occupation and, if possible, by grade. Because NAVPERSRANDCEN is not a large activity, recruiting requirements can only be forecasted for the four groups identified previously. All that is needed by HIREST is the personnel data file for all employees (described above) and the desired number of personnel on board at the end of each future fiscal year. Using the previously developed procedures, HIREST forecasts the number of hires required to achieve NAVPERSRANDCEN's total personnel requirements through FY82. The results of that forecast are given in Table 6. In this exercise, the begin date was 1 July 1980. To reflect that date, the NAVPERSRANDCEN employee file as of 1 October 1979 was updated by the new hires and losses occurring through 1 July 1980. Desired end-year personnel totals for FY80, FY81, an FY82 were specified for each of the four groups (e.g., 180, 185, 194 for Group 1). Note that the (Base) period covers 1 July 1980--1 October 1980 (4 months); hence, the smaller magnitude of losses and gains for that period. Note that HIREST also forecasts attrition of the new hires. Thus, the total number of new hires needed is sometimes more than one might expect, because some of the new hires during a fiscal year will leave before the end of that fiscal year. A uniform hiring practice is assumed; however, the user may use HIREST to front-load or back-load hires.

Based on the log-probability equations derived from 4 years historical data and given the desired end year strengths by group, a total of 10 people in the remainder of FY80, 42 in FY81, and 45 in FY82 need to be hired (and many more than that recruited). It is still necessary to determine how to distribute the new hires by GS series within each of the four groups.

CONCLUSION

This methodology offers promise in forecasting staffing needs at institutions similar to NAVPERSRANDCEN.

Table 6

Forecasting Requirements

Item	Base	1981	1982
Group 1: Professionals			
Population:			
Start	182	180	185
End	180	185	194
Est. Losses	5	15	16
Est. Gains	3	20	25
Group 2: Admin./Tech.			
Population:			
Start	44	44	45
End	44	45	45
Est. Losses	2	6	6
Est Gains	2	7	6
Group 3: Clerical			
Population:			
Start	33	32	33
End	32	33	35
Est. Losses	4	9	8
Est. Gains	3	10	10
Group 4: Secretarial			
Population:			
Start	15	15	16
End	15	16	16
Est. Losses	2	4	4
Est. Gains	2	5	4

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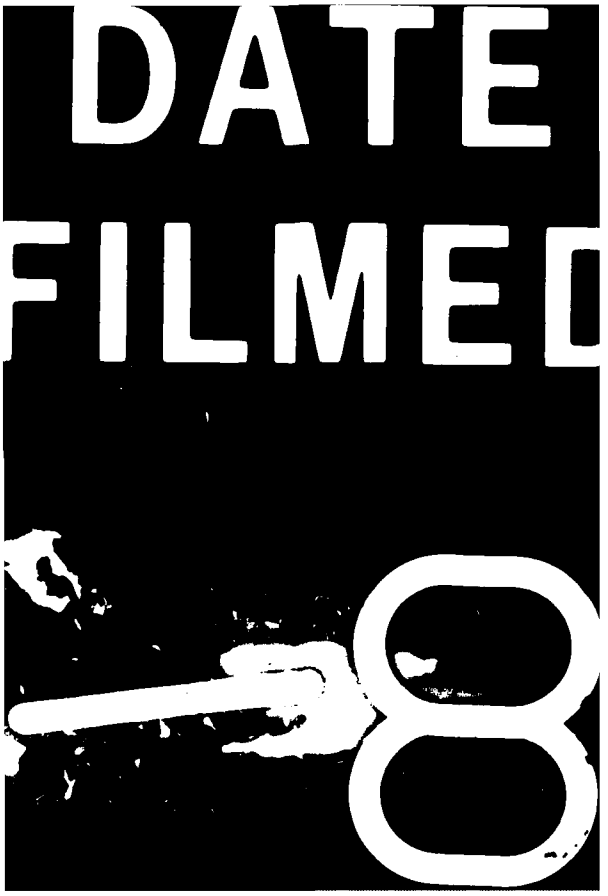
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